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GOLF CLUB HEAD MADE OF METAL

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to golf club heads made of a metal. More specifically, the present invention relates to heads for golf clubs, such as woods, irons, and utility clubs, which are made of a metal and have excellent flight distance properties and durability.

Description of Related Art

In general, metal golf club heads, such as those for woods, irons, and utility clubs, are constructed by separately forming a face member, a crown member, a sole member, a hosel member and so forth, welding each of the members to form a single piece, and subjecting the piece to a heat treatment. After that, the golf club head obtained is balanced and polished to form the final product. The face member of the golf club may be made by subjecting the metal to a sheet metal working process. Also, it is possible to subject the face member to further surface treatment processes, such as plating or ion plating processes, to improve the flight distance performance and durability thereof. There are other types of golf club head structures, such as the three-piece and the two piece types, in addition to the above-mentioned four-piece type.

In conventional golf club heads, however, there are the problems that the flight distance and durability are insufficient even if the face member thereof is subjected to a surface treatment process, such as plating or ion plating.

SUMMARY OF THE INVENTION

The present invention takes into consideration the above-mentioned circumstances, and has an object of providing a golf club head having excellent flight distance and durability.

The inventors of the present invention, after diligent studies to achieve the above object and intense testing of various materials and structures for golf club heads, have found that the flight distance performance may be improved by decreasing the hardness of a peripheral portion of a ~~hitting face as compared with the~~ hardness of a center part thereof. Also, the inventors of the present invention have found that the hardness of the peripheral portion of the hitting face may be decreased by subjecting only the face part to a heat treatment process and then welding it to the other members, rather than welding each member first and then subjecting the welded piece to a heat treatment process as in conventional processes.

Accordingly, the present invention provides a golf club head, including a ball hitting face which includes a central portion and a peripheral portion surrounding at least a part of the central portion, wherein the golf club head is made of a metal, and the hardness of the peripheral portion is lower than the hardness of the central portion.

The present invention also provides a golf club head, including a face member forming a ball hitting face, the ball hitting face including a central portion and a peripheral portion surrounding at least a part of the central portion, wherein the golf club head is manufactured by a method comprising the steps of: forming the face member from a raw material separately from the other members used for the golf club head; and subsequently welding the other members to the face member at the periphery of the face member, the golf club head being made of a metal, and the hardness of the peripheral portion is lower than the hardness of the central portion.

In accordance with another aspect of the invention, the width of the peripheral

portion of the hitting face is in the range between about 5 and 20 mm, the width of the peripheral portion being determined by measuring the hardness distribution of the hitting face from an arbitrary point A on the opposite edge of the hitting face, passing through the center of the hitting face, to a point B on the opposite edge of the hitting face; determining the hardness of the central portion by taking the average of the hardness measured in an area in the vicinity of the center of the hitting face where the difference in hardness in the area is in the range of ±5%; determining the hardness of the peripheral portion in the vicinity of the point A by taking the average of the hardness measured in an area in the vicinity of the point A where the difference in hardness in the area is in the range of ±5%; determining a point of measurement having a value of the hardness closest to the mean value between the hardness of the central portion and the hardness of the peripheral portion; and determining the width of the peripheral portion as the distance between the point A and the point of measurement.

In accordance with yet another aspect of the invention, the difference in the hardness between the central portion and the peripheral portion of the ball hitting face is equal to or greater than 50 in terms of the Vickers hardness, the hardness of the central portion and of the peripheral portion being determined by measuring the hardness distribution of the hitting face from an arbitrary point A on the edge of the hitting face, passing through the center of the hitting face, to a point B on the opposite edge of the hitting face; determining the hardness of the central portion by taking the average of the hardness measured in an area in the vicinity of the center of the hitting face where the difference in hardness in the area is in the range of ±5%; and determining the hardness of the peripheral portion in the vicinity of the point A by taking the average of the hardness measured in an area in the vicinity of the point A where the difference in hardness in the area is in the range of ±5%.

BRIEF DESCRIPTION OF THE DRAWINGS

Some of the features and advantages of the invention having been described, others will become apparent from the detailed description which follows, and from the accompanying drawings, in which:

FIG. 1 is a schematic diagram showing the face part of a golf club head according to an embodiment of the present invention;

FIG. 2A is a schematic diagram showing the face part of a golf club (wood) head according to Example 1 of the present invention;

FIG. 2B is a graph showing the hardness distribution of the golf club head shown in FIG. 2A;

FIG. 3A is a schematic diagram showing the face part of a golf club (iron) head according to Example 7 of the present invention; and

FIG. 3B is a graph showing the hardness distribution of the golf club head shown in FIG. 2A.

DETAILED DESCRIPTION OF THE INVENTION

The invention summarized above and defined by the enumerated claims may be better understood by referring to the following detailed description, which should be read with reference to the accompanying drawings. This detailed description of particular preferred embodiments, set out below to enable one to build and use particular implementations of the invention, is not intended to limit the enumerated claims, but to serve as particular examples of the invention.

FIG. 1 is a schematic diagram showing a face part of a golf club head according to an embodiment of the present invention. Note that in FIG. 1, although a face part 1 of

a golf club (wood) head is integrally formed with the hosel 1a according to this embodiment of the present invention, the present invention is not limited in this way, and the face part 1 and the hosel 1a may be separately formed. Also, in FIG. 1, the face part 1 is welded to other members which form, for instance, a sole and a crown, at the peripheral portion thereof so as to form the head of the club. Accordingly, the face part 1 is made of at least one raw material separately from the other members, however, the other members, such as the sole and the crown, may be formed integrally with or separately from the other members.

In FIG. 1, the hardness of a peripheral portion 3 of the face part 1 is lower than the hardness of a central portion 2 of the face part 1. In the face part 1, it is preferable that the width W (W1 and W2) of the peripheral portion 3 from an edge thereof toward the center of the face part 1 be in the range between about 5 and 20 mm. Also, it is preferable that the difference in the Vickers hardness between the central portion 2 and the peripheral portion 3 be 50 or greater. If the difference in the Vickers hardness between the central portion 2 and the peripheral portion 3 is 50 or greater, and the width W of the peripheral portion 3 is in the range between about 5 and 20 mm, the flight distance performance of the club head is improved and the durability thereof may be enhanced. It is preferable, on the other hand, that the Vickers hardness of the central portion 2 be 500 or less. If the Vickers hardness of the central portion 2 exceeds 500, the flight distance performance and the durability of the club head are reduced. In addition, although the explanation is given for a wood club head in the above embodiment, it is also preferable that the hardness of a peripheral portion 3 be lower than the hardness of a central portion 2 for, for instance, an iron and a utility club head.

In the following, an explanation will be given for the hardness of the peripheral portion 3 and that of the central portion 2, and the width W of the peripheral portion 2 in

the embodiment according to the present invention. The Vickers hardness of the face part 1 shown in FIG. 1 is measured from the point A on the edge of the peripheral portion 3 to the point B on the opposite edge of the peripheral portion 3 passing through the point O, which is located at the center, and the hardness distribution of the face part 1 is obtained. Then, the average hardness of plateau portions in the vicinity of the point O is calculated with respect to the hardness distribution obtained. The plateau portion may be defined, for example, as an area where the difference in hardness is in the range of ±5%, and the average hardness of the plateau portions obtained is used as the hardness in the central portion 2. Also, the average hardness of the plateau portions in the vicinity of the points A and B, respectively, on the edges of the peripheral portion 3 is obtained. The plateau portion in the vicinity of the points A and B may also be defined as an area where the difference in hardness is in the range of ±5%, and the average hardness of the plateau portions obtained for each of the points A and B is further averaged to be used as the hardness of the peripheral portion 3.

Also, the width W in the peripheral portion 3 may be calculated as follows. A mean value of the hardness between the peripheral portion 3 and the central portion 2 is obtained. Then, a point A1 and a point B1 having a hardness corresponding to the mean value obtained are determined, and the width W1, i.e., the width from the point A on the edge of the peripheral portion 3 to the point A1, and the width W2, i.e., the width from the point B on the edge of the peripheral portion 3 to the point B1, are measured. Finally, the average of the width W1 and the width W2 is calculated to obtain the width W, which is used as the width of the peripheral portion 3.

Next, a method for manufacturing a golf club head according to a second embodiment of the present invention will be explained.

First, the face member, the sole member, and the crown member, are produced by

molding a metal, such as a titanium alloy, using, for instance, a sheet metal working process. The hosel member may be produced, for instance, by machining. Note that the face member and the hosel member may be integrally formed as mentioned above. Then, only the face member is subjected to a heat treatment process. The heat treatment process may be performed by carrying out an aging treatment after a solution treatment, or by carrying out only the aging treatment. The solution treatment may be carried out for about four to six minutes at a temperature of about 700-900°C. Also, the aging treatment may be carried out in air for about five to ten hours at a temperature of about 400-600°C. After the face member is subjected to the heat treatment process, the sole, the crown, and the hosel members are welded to the face member to obtain a golf club head. It is preferable to carry out the welding process in an argon atmosphere using a welding current of about 30-90A.

If the face member is subjected to the aging process prior to the welding process, the peripheral portion of the face part is heated by the welding heat applied during the welding process and the hardness of the peripheral portion is decreased. Note that a metal other than the titanium alloy may be used according to the embodiments of the present invention as long as the strength of the metal is increased by a solution treatment and a heat treatment, such as an aging treatment, to obtain the effect of decreasing the hardness of the peripheral portion in the welding process after the heat treatment process. If the hardness of the peripheral portion of the face part is decreased as mentioned above, the hardness of the central portion, which forms a hitting face, is relatively increased and a spring effect is obtained as a result of the peripheral portion having a lower hardness than the central portion so that the flight distance performance of the club head is improved compared to conventional club heads in which the hardness of the face part is uniform. Moreover, the durability of the golf club head according to the embodiment of the present

invention is improved since the impact applied to the hitting face is absorbed by the entire club head, rather than only by the face part as in conventional club heads, because the strain is born by the entire club head as a result of the lower hardness of the peripheral portion.

As explained above, according to the present invention, the hardness of the peripheral portion of the face part can be decreased compared to the hardness of the central portion thereof by subjecting the face member to a heat treatment prior to a welding process. Also, the size of the peripheral portion of the face part may be controlled by the level of the welding current used for welding the face member to the other members. That is, the area of the peripheral portion having a small hardness is enlarged when the welding current is increased, and hence, the area of the peripheral portion may be decreased by using a smaller welding current. If the hardness of the peripheral portion of the face part is decreased as compared with that of the central portion in the above mentioned manner, the flight distance performance of the golf club head is enhanced and the durability thereof is improved. Note that according to the present invention, any production method may be adopted as long as the hardness of the peripheral portion can be made smaller than the hardness of the central portion thereof, and therefore, the golf club head need not be produced by a method in which the face part is separately formed and subjected to a heat treatment process prior to a welding process as explained in the above embodiment.

Examples:

In the following, the effect of the present invention will be explained by comparing golf club heads according to the present invention with the golf club heads of comparative examples.

Example 1:

A face member, a sole member, and a crown member were constructed by using a titanium alloy and employing a sheet metal working process. Also, a hosel member was manufactured by means of machining. The face member was constructed by using a β-type titanium alloy and was subjected to an aging process at 430°C for ten hours. In this manner, i.e., by carrying out the aging process prior to the welding process, the hardness of the peripheral portion of the face part was decreased as compared with that of the central portion. Then, the face member, the sole member, the crown member, and the hosel member were welded in an argon atmosphere, and the welded piece was polished to produce the golf club (wood) head of Example 1 which is shown in FIG. 2A.

Example 2:

A face member, a sole member, and a crown member, respectively, were constructed by using a titanium alloy and employing a sheet metal working process. Also, a hosel member was manufactured by means of machining. The face member was constructed by using an $\alpha+\beta$-type titanium alloy and was subjected to an aging process at 700°C for two hours. Then, the face member, the sole member, the crown member, and the hosel member were welded in an argon atmosphere, and the welded piece was polished to produce the golf club (wood) head of Example 2.

Example 3:

In Example 3, the face member was constructed by using an as-roll β-type titanium alloy, which was not annealed due to the use of a cold-rolling process, and employing a sheet metal working process. Members other than the face member, i.e., the crown member and the sole member, were constructed by using pure titanium and employing a sheet metal working process. Also, a hosel member was manufactured by processing a round bar of a pure titanium. The face member was subjected to an aging

process in air at 430°C for 30 minutes. Then, the face member, the sole member, the crown member, and the hosel member were welded in an argon atmosphere using a current of 60A, and the welded piece was polished to obtain the golf club (wood) head of Example 3. Accordingly, only the material used for the face member and time for the aging process in Example 3 were different from those in Example 1.

Example 4:

In Example 4, each of the members was constructed using the same material as in Example 1, and the face member was subjected to an aging process in air at 430°C for ten hours as in Example 1. After this, a golf club (wood) head of Example 4 was constructed using different welding conditions from Example 1, i.e., a welding current of 90A, which was 1.5 times greater than that used in Example 1, was used in the welding process carried out in an argon atmosphere. After the polishing process, a golf club (wood) head of Example 4 made of the same materials having the same shape as the club head of Example 1 was obtained. The width of the peripheral portion of the face part of the club head having a smaller hardness was 22 mm since the welding current was increased.

Example 5:

In Example 5, each of the members was constructed using the same material as in Example 1, and the face member was subjected to an aging process in air at 430°C for ten hours as in Example 1. After this, a golf club (wood) head of Example 5 was constructed using different welding conditions from Example 1, i.e., a welding current of 30A, which was half of that used in Example 1, was employed in the welding process carried out in an argon atmosphere. After the polishing process, a golf club (wood) head of Example 5 made of the same materials having the same shape as the club head of Example 1 was obtained. The width of the peripheral portion of the face part of the club head having a smaller hardness was 3 mm since the welding current was decreased.

Example 6:

In Example 6, the face member was constructed by using a β-type titanium alloy, and employing a sheet metal working process. Members other than the face member, i.e., the crown member and the sole member, were constructed by using pure titanium and employing a sheet metal working process. Also, a hosel member was manufactured by processing a round bar of pure titanium. Then, the face member was subjected to an aging process at 430°C for 30 minutes. After this, the face member, the sole member, the crown member, and the hosel member were welded in an argon atmosphere using a current of 60A, and the welded piece was polished to obtain the golf club head of Example 6. Accordingly, only the time for the aging process in Example 6 was different from that in Example 1, and the other conditions, the shapes of each part, and the head specifications were the same as those in Example 1.

Example 7:

In Example 7, an iron head was manufactured. The face member of the iron head was constructed using a titanium alloy and employing a sheet metal working process. Members other than the face member, i.e., the hosel member and the frame member, were cast integrally. Since the face member was constructed by using a β-type titanium alloy, it was subjected to an aging process at 430°C for ten hours. After this, the two parts were welded in an argon atmosphere using a current of 60A and the welded piece was polished to obtain the golf club (iron) head of Example 7 shown in FIG. 3A.

Comparative Example 1:

For comparison with the golf club head in Example 1, a golf club (wood) head having the same shape as in Example 1 was constructed by using a conventional method. That is, a face member, a sole member, a crown member, and a hosel member were processed so as to be the same as those in Example 1 by employing a sheet metal working

process and machining. Then, each of the members was welded in an argon atmosphere. After this, the welded piece was subjected to an aging process in air at 430°C for ten hours. After polishing, the golf club (wood) head of Comparative Example 1 was obtained.

Comparative Example 2:

For comparison with the golf club head in Example 7, a golf club (iron) head having the same shape as in Example 7 was constructed by using a conventional method. That is, a face member, a sole member, a crown member, and a hosel member were processed in the same manner as in Example 7, and the four members were welded in an argon atmosphere using a current of 60A. After this, the welded piece was subjected to an aging process at 430°C for ten hours to obtain the golf club (iron) head of Comparative Example 2. The manufacturing conditions used and properties obtained for the golf club head of Examples 1-7 and Comparative Examples 1 and 2 are shown in Table 1 below.

Table 1

	Head	Material	Aging process		Welding current (A)	Hardness (center)	Hardness (periphery)	Difference in hardness	W
				Conditions (℃×hr)					
Ex.1	wood	β	P	430×10	60	340	260	80	8
Ex.2		α+β	P	700×2	60	400	350	50	10
Ex.3		β	P	430×0.5	60	460	260	200	5
Ex.4		β	P	430×10	90	340	260	80	22
Ex.5		β	P	430×10	30	340	260	80	3
Ex.6		β	P	430×0.5	60	280	260	20	5
C.E.1		β		430×10	60	340	340	0	0
Ex.7	Iron	β	P	430×10	60	340	260	80	8
C.E.2		β		430×10	60	340	340	0	0

* β: β type titanium alloy; α+β: α+β type titanium alloy; P: prior to the welding process; A: after the welding process; and W: width.

Also, the hardness distribution in the face part of each golf club head was

measured. In practice, each of the golf club heads was cut in the direction from the upper portion of the golf club head to the sole member, and the Vickers hardness from one end of the cut surface to the other end was measured with an interval between about 1.2 and 1.6 mm. The hardness of the peripheral portion and the central portion was obtained based on the results of the measurements. Then, the mean values between the hardness of the peripheral portion and that of the central portion were calculated to determine the point of measurement having the hardness closest to the mean value, and this point of measurement was used as the boundary defining the peripheral portion and the central portion. In Table 1 above, the hardness of the peripheral portion and the central portion, the difference in hardness between the two, and the width of the peripheral portion are also shown.

FIG. 2B is a graph showing the Vickers hardness at a cut surface 10 of a golf club (wood) head of Example 1 shown in FIG. 2A in comparison with that of a golf club head of Comparative Example 1. In FIG. 2B, the Vickers hardness of the golf club head of Example 1 is indicated by circular dots (●), and that of the golf club head of Comparative Example 1 is indicated by triangular dots (▲). Also, FIG. 3B is a graph showing the Vickers hardness at a cut surface 20 of a golf club (iron) head of Example 7 shown in FIG. 3A in comparison with that of a golf club head of Comparative Example 2. In FIG. 3B, the Vickers hardness of the golf club head of Example 7 is indicated by circular dots (●), and that of the golf club head of Comparative Example 2 is indicated by triangular dots (▲). The hardness of the peripheral portion and that of the central portion, and the width of the peripheral portion were calculated by using the method described above with respect to the hardness distribution of the face part of each. For example, in the golf club head of Example 1 shown in FIG. 2A, the average hardness in the area in the vicinity of

the points A and B having the difference in hardness in the range of ±5% was 260, and the average hardness in the area in the vicinity of the point O having the difference in hardness in the range of ±5% was 340. Accordingly, the mean value calculated from the above mentioned average hardness was 300. The point of measurement having the hardness closest to 300 was located 8 mm away from the point A, and 7.5 mm away from the point B. Therefore, the width W of the peripheral portion was determined to be about 8 mm which is the average between the two. Accordingly, the peripheral portion of the face part was defined as the area having the width W of 8 mm. The hardness distribution of the golf club head of Example 7 shown in FIG. 3A and of other Examples and Comparative Examples, respectively, was measured in the same manner as above, and the hardness of the peripheral portion and the central portion, and the width of the peripheral portion of each were calculated based on the hardness distribution obtained.

Next, methods used for evaluating the golf club head of Examples 1-7 and Comparative Examples 1 and 2 will be explained. Each of the golf club heads was tested for its flight distance performance. The flight performance test was carried out by attaching a shaft to the club head of each Examples and Comparative Examples to be used as a golf club, and a golf club testing robot was used to hit a golf ball at the center of the face part of the club head at a head speed of 40 m/sec. The test was repeated 10 times for each of the golf club heads and the flight distance of the golf ball measured is shown in Tables 2 and 3 below.

Table 2

	Flight distance (m)		
	Minimum	Average	Maximum
Ex. 1	226	230	233
C. Ex.1	216	219	223

Table 3

	Flight distance (m)		
	Minimum	Average	Maximum
Ex. 7	167	170	172
C. Ex.2	161	165	167

Also, each of the club heads was tested for durability. After hitting golf balls 3,000, 6,000, and 9,000 times using the club head at a head speed of 40 m/sec, the central portion of the face part of the club head was observed by naked eye to determine if cracks or dents occurred. The results of the durability test are shown below in Tables 4 and 5 for the club head of Example 1 and Comparative Example 1, and of Example 7 and Comparative Example 2, respectively. Also, the results of the evaluation of each of the club heads are tabulated in Table 6.

Table 4

	After 3,000 balls hit	After 6,000 balls hit	After 9,000 balls hit
Ex. 1	No change	No change	No change
C. Ex.1	No change	Crack at center of face part	-

Table 5

	After 3,000 balls hit	After 6,000 balls hit	After 9,000 balls hit
Ex. 7	No change	No change	No change
C. Ex.2	No change	Crack at center of face part	-

Table 6

	Head	Durability test			Flight distance test
		3,000 balls	6,000 balls	9,000 balls	Ave. flight distance (m)
Ex. 1	Wood	N. C.	N. C.	N. C.	230
Ex. 2		N. C.	N. C.	N. C.	228
Ex. 3		N. C.	N. C.	Crack	227
Ex. 4		N. C.	N. C.	Dent	228
Ex. 5		N. C.	N. C.	Crack	222
Ex. 6		N. C.	N. C.	Dent	221
C.Ex.1		N. C.	Crack	-	219
Ex. 7	Iron	N. C.	N. C.	N. C.	170
C. Ex.2		N. C.	Crack	-	165

*N. C.: no change

As shown in Table 6 above, a crack occurred in the face part of the club head of Comparative Example 1 before hitting 6,000 balls in the durability test due to the fact that the hardness of the peripheral portion and the central portion thereof were the same. Also, the flight distance of the club head of Comparative Example 1 was only 219 m, which is relatively short.

On the other hand, no cracks or dents occurred in the face part of the club heads of Examples 4 through 6 after hitting 6,000 balls during the durability test due to the fact that the hardness of the peripheral portion is lower than that of the central portion thereof. Accordingly, the durability of the club heads is higher than that of Comparative Examples 1 and 2, and the flight distance of each of the club heads is also higher.

As shown in FIG. 2B, the difference in the Vickers hardness of the club head of Example 1 between the central portion and the peripheral portion thereof is 80, and the width of the peripheral portion is 8 mm. Also, the differences in the Vickers hardness of the club heads of Examples 2 and 3 between the central portion and the peripheral portion

thereof are 50 and 200, respectively, and the widths of the peripheral portions are 10 and 5 mm, respectively. That is, the width of the peripheral portion of the face part and the difference in hardness between the peripheral portion and the central portion of the club heads of Examples 1 through 3 are in the preferable range according to the embodiments of the present invention, and hence, the durability and the flight distance performance of these club heads are superior to those of the club heads of Examples 4 through 6. However, since the Vickers hardness of the central portion of the club head of Example 3 was 460, which is slightly higher than that of the club heads of Examples 1 and 2, a minor crack occurred on the face part thereof before hitting 9,000 balls, and the durability as well as the flight performance thereof were slightly decreased.

As for the iron club head of Comparative Example 2, since the hardness distribution in the face part thereof was constant, cracks occurred on the face part before hitting 6,000 balls during the durability test and the flight performance thereof was also unsatisfactory. On the other hand, since the difference in the Vickers hardness of the club head of Example 7 between the central portion and the peripheral portion thereof is 80, and the width of the peripheral portion is 8 mm, both of which are in the preferable range according to the embodiments of the present invention, the flight distance performance and the durability thereof are significantly improved as compared with the club head of Comparative Example 2 as shown in Tables 3 and 5.

Accordingly, as mentioned above, according to the embodiments of the present invention, a golf club head having excellent flight distance performance and durability are obtained because the hardness of the peripheral portion of the face part is decreased as compared with that of the central portion.

Having thus described several exemplary embodiments of the invention, it will be apparent that various alterations, modifications, and improvements will readily occur to

those skilled in the art. Such alterations, modifications, and improvements, though not expressly described above, are nonetheless intended and implied to be within the spirit and scope of the invention. Accordingly, the invention is limited and defined only by the following claims and equivalents thereto.